

PATENT ABSTRACTS OF JAPAN

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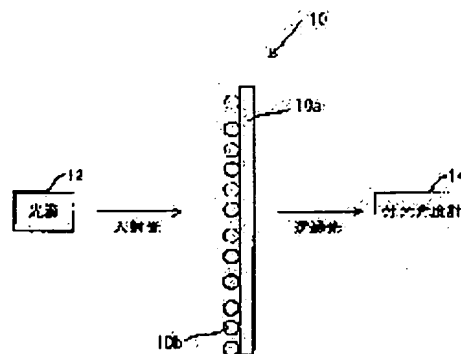
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(54) LOCALIZED PLASMON RESONANCE SENSOR

(57)Abstract:

PROBLEM TO BE SOLVED: To enable the subject sensor to arrange at a narrow place to be adapted to a sample having an arbitrary shape including a curved shape and to permit the construction of the sensor on the inner surface of a tubular body such as a glass pipe.

SOLUTION: A sensor unit 10 constituted so as to have a glass substrate 10a and the gold fine particles 10b fixed on the surface of the surface of the substrate 10a in a membrane form is provided to be irradiated with light, and the absorbancy of the light transmitted through the gold fine particles 10b fixed on the substrate 10a is measured to detect the refractive index of a medium present in the vicinity of the gold fine particles 10b fixed on the substrate 10a.



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CLAIMS

(57) [Claim(s)]

[Claim 1] It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and said substrate condensing. The localization plasmon resonance sensor which is what detects the refractive index of the medium near [which was fixed to said substrate by irradiating light to said sensor unit and measuring the absorbance of the light which penetrated said metal particle fixed to said substrate / said] the metal particle.

[Claim 2] It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and said substrate condensing. By irradiating light to said sensor unit and measuring the absorbance of the light which penetrated said metal particle fixed to said substrate The localization plasmon resonance sensor which is what detects the refractive index of the medium near [which was fixed to said substrate / said] the metal particle, and detects adsorption or deposition of the matter to said metal particle fixed to said substrate of said sensor unit according to this detection result.

[Claim 3] It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and said substrate condensing. By irradiating light to said sensor unit arranged in a liquid, and measuring the absorbance of the light which penetrated said metal particle fixed to said substrate The localization plasmon resonance sensor which is what measures the refractive index of the liquid with which the refractive index of the medium near [which was fixed to said substrate / said] the metal particle was detected, and said sensor unit has been arranged according to this detection result.

[Claim 4] Said substrate [in / on a localization plasmon resonance sensor given in any 1 term of claim 1, claim 2, or claim 3 and / said sensor unit] is a localization plasmon resonance sensor which is what is a glass substrate.

[Claim 5] Said metal particle [in / on a localization plasmon resonance sensor given in any 1 term of claim 1, claim 2, claim 3, or claim 4 and / said sensor unit] is a localization plasmon resonance sensor which is what is the particle of gold with a diameter of 10-20nm.

[Claim 6]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is further used for a detail like the existence of adsorption of the antigen in an antigen-antibody reaction about a localization plasmon resonance sensor as an affinity sensor which detects the existence of adsorption of the matter, and relates to a suitable localization plasmon resonance sensor.

[0002]

[Description of the Prior Art] Before, for example, the surface plasmon resonance sensor was used as an affinity sensor for detecting the existence of adsorption of the matter like the existence of adsorption of the antigen in an antigen-antibody reaction.

[0003] Generally this surface plasmon resonance sensor The sensor unit constituted by having the metal membrane which is formed in the whole surface of prism and the prism concerned, and contacts a sample, The light source which generates the light beam for carrying out incidence to the prism of this sensor unit, An optical-system means to carry out incidence of the light beam generated according to this light source to a sensor unit as various incident angles can be acquired to the interface of the prism of a sensor unit, and a metal membrane, It has a detection means to detect the total reflection luminous intensity reflected by the interface of prism and a metal membrane by the incidence of the light beam from the light source to a sensor unit for every various incident angles, and is constituted.

[0004] Therefore, since the sensor unit needed prism as the component, a surface plasmon resonance sensor which was described above had the trouble that arranging prism could not arrange a sensor unit in a difficult narrow location.

[0005] Moreover, in order to obtain the high detection result of precision by the surface plasmon resonance sensor, the whole surface of the prism which forms the metal membrane which contacts a sample in a sensor unit needed to be formed in the smooth flat side, and there was a trouble that a surface plasmon resonance sensor could not be built to the sample of a curved-surface configuration for this reason.

[0006] Moreover, generally the metal membrane formed in the whole surface of prism in a sensor unit is formed using the vacuum deposition method.

[0007] However, there was a trouble that it was difficult to make the inside of the tubular object of a glass tube etc. vapor-deposit a metal membrane depending on a vacuum deposition method, therefore a surface plasmon resonance sensor could not be built in the inside of the tubular object of a glass tube etc.

[0008]

[Problem(s) to be Solved by the Invention] The place which this invention is made in view of the various troubles which a Prior art which was described above has, and is made into the purpose tends to offer the localization plasmon resonance sensor which made it possible to arrange in a narrow location.

[0009] Moreover, the place made into the purpose of this invention tends to offer the localization plasmon resonance sensor which made it possible to use to the sample of the configuration of arbitration

including a curved-surface configuration.

[0010] Furthermore, it is going to offer the localization plasmon resonance sensor which made it possible to build the place made into the purpose of this invention in the inside of the tubular object of a glass tube etc.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, what fixed the metal particle to the front face of the substrate of the ingredient of arbitration, such as a dielectric, a metal, or a semi-conductor, in the shape of film is used for this invention as a sensor unit. By irradiating light to this sensor unit and measuring the absorbance of the light which penetrated the metal particle fixed to the substrate The refractive index of a certain medium can be detected by the distance of diameter extent near [which was fixed to the substrate] the metal particle front face (for example, the metal particle fixed to the substrate), consequently adsorption and deposition of the matter to the metal particle of a sensor unit can be detected now.

[0012] Moreover, since this invention detects the refractive index of a certain medium by the distance of diameter extent near [which was fixed to the substrate] the metal particle front face (for example, the metal particle fixed to the substrate), when the sensor unit has been arranged in a liquid, it can also measure the refractive index of the liquid concerned.

[0013] Here, in case a metal particle is formed in the shape of film on the surface of a substrate, it is desirable to form a metal particle as monolayer and to be fixed in the condition of having separated mutually, moreover, without a metal particle hardly condensing.

[0014] The conceptual explanatory view of the localization plasmon resonance sensor by above-mentioned this invention is shown in drawing 1 , the metal particles 3, such as gold and silver, are fixed to a substrate 2, and the sensor unit 1 is constituted.

[0015] And it carries out incidence to a substrate 2 to it, using light of transparent wavelength as incident light to this sensor unit 1. If it does so, incidence of the incident light which penetrated the substrate 2 will be carried out to the metal particle 3, and outgoing radiation of the incident light which penetrated the metal particle 3 will be carried out outside as the transmitted light.

[0016] Here, if incidence of the light is carried out to metal particles, such as gold and silver, the scattered light and absorption will increase in a certain wavelength, a resonance peak will appear, and a resonance wavelength will be dependent on the refractive index of a surrounding medium with localization plasmon resonance at this time. And the absorbance of a resonance peak becomes large and it comes to shift it to a long wavelength side as the refractive index of the surrounding medium of a metal particle becomes large.

[0017] In addition, it is as follows when the conditions of the localization plasmon resonance in the isolated metal particle are shown.

[0018] First, if it assumes that a metal particle is a globular form, the polarizability alpha will be given with a formula 1.

[Equation 1]

$$\alpha = 4\pi a^3 \frac{\epsilon_m - \epsilon_0}{\epsilon_m + 2\epsilon_0}$$

... a formula 1 -- here, as for a, the radius of a ball, epsilon_m, and epsilon₀ are the dielectric constants of a metal particle and a medium, respectively.

[0019] Therefore, [Equation 2]

$$\text{Re}(\epsilon_m) + 2\epsilon_0 = 0$$

... Resonance arises at the time of a formula 2, and the polarizability of a particle becomes max.

[0020] On the other hand, the quenching cross section C_{ext} of a particle is given by the degree type (formula 3) using polarizability alpha.

[Equation 3]

$$C_{\text{ext}} = \frac{2\pi}{\lambda} \text{Im}(\alpha)$$

... a formula 3 -- here, lambda is the wavelength of incident light.

[0021] Therefore, in the resonance conditions given with a formula 2, the quenching cross section C_{ext} of a particle serves as max, and is given by the degree type (formula 4).

[Equation 4]

$$C_{\text{ext}} = \frac{24\pi^2 a^3 (\epsilon_0)^{3/2}}{\lambda \text{Im}(\epsilon_m)}$$

... If the absorption spectrum of the transmitted light which penetrated the formula 4, therefore the metal particle 3 is measured using a spectrophotometer and the absorbance to each wavelength is obtained, as a localization plasmon phenomenon shows to [drawing 2](#), in predetermined wavelength, a resonance peak will appear with the relation between the dielectric constant of the metal particle 3, and the dielectric constant of a surrounding medium ((a) in [drawing 2](#)).

[0022] And the matter has not adsorbed and deposited this absorbance at the metal particle 3, and when the surrounding medium of the metal particle 3 concerned is air, it is measured. When the matter with a bigger refractive index than air sticks to the metal particle 3, or it deposits and the matter concerned functions as a surrounding medium of the metal particle 3 concerned, the absorbance of a resonance peak becomes large and it comes ((b) in [drawing 2](#)) to shift it to a long wavelength side.

[0023] Therefore, in this invention, by measuring the absorbance of the transmitted light by which outgoing radiation is carried out from the sensor unit 1, the refractive index of a certain medium can be detected by the distance near the front face of the metal particle 3 (for example, diameter extent of the metal particle 3), and the adsorption and the deposition of the matter to the metal particle 3 which were fixed to the substrate 2 of the sensor unit 1 can be detected now.

[0024] Moreover, when the sensor unit 1 has been arranged in a liquid, the refractive index of the liquid concerned can also be measured.

[0025] and the sensor unit 1 makes the metal particle 3 fix to a substrate 2, without needing prism etc. -- being sufficient -- since -- it can arrange in a narrow location.

[0026] Moreover, since you may form in the configuration of arbitration including a curved-surface configuration, the substrate 2 of the sensor unit 1 can be used to the sample of the configuration of arbitration including a curved-surface configuration.

[0027] Furthermore, since immobilization of the metal particle 3 to a substrate 2 can be performed chemically, it can build in the inside of the tubular object of a glass tube etc.

[0028] In this invention in addition, the relation between a substrate and incident light As explained in the above, it may be made to carry out incidence to a substrate 2, using light of transparent wavelength as incident light, referring to [drawing 1](#), and as shown in [drawing 3](#) metal particle 3' fixed to substrate 2' in the light of wavelength which is reflected to substrate 2' -- as incidence is carried out from a side, you may make it measure the absorbance of the reflected light from sensor unit 1', i.e., the transmitted light which penetrated metal particle 3'

[0029] In a viewpoint which was described above among this inventions invention according to claim 1 It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and the above-mentioned substrate condensing. Light is irradiated to the above-mentioned sensor unit, and the refractive index of the medium near [which was fixed to the above-mentioned substrate / above-mentioned] the metal particle is detected by measuring the absorbance of the light which penetrated the above-mentioned metal particle fixed to the above-mentioned substrate.

[0030] Among this inventions, moreover, invention according to claim 2 It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and the above-mentioned

substrate condensing. By irradiating light to the above-mentioned sensor unit, and measuring the absorbance of the light which penetrated the above-mentioned metal particle fixed to the above-mentioned substrate The refractive index of the medium near [which was fixed to the above-mentioned substrate / above-mentioned] the metal particle is detected, and adsorption or deposition of the matter to the above-mentioned metal particle fixed to the above-mentioned substrate of the above-mentioned sensor unit is detected according to this detection result.

[0031] Among this inventions, moreover, invention according to claim 3 It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and the above-mentioned substrate condensing. By irradiating light to the above-mentioned sensor unit arranged in a liquid, and measuring the absorbance of the light which penetrated the above-mentioned metal particle fixed to the above-mentioned substrate The refractive index of the medium near [which was fixed to the above-mentioned substrate / above-mentioned] the metal particle is detected, and the refractive index of the liquid with which the above-mentioned sensor unit has been arranged is measured according to this detection result.

[0032]

[0033] Moreover, it is made for the above-mentioned substrate [in / in / among this inventions / invention given in any 1 term of claim 1, claim 2, or claim 3 / in invention according to claim 4 / the above-mentioned sensor unit] to be a glass substrate among this inventions.

[0034] Moreover, it is made for the above-mentioned metal particle [in / in / among this inventions / invention given in any 1 term of claim 1, claim 2, claim 3, or claim 4 / in invention according to claim 5 / the above-mentioned sensor unit] to be a particle of gold with a diameter of 10-20nm among this inventions.

[0035] Among this inventions, moreover, invention according to claim 6 It sets to invention according to claim 4 among this inventions. The above-mentioned sensor unit Fix a golden particle to the front face of the above-mentioned glass substrate as the above-mentioned metal particle, and it comes to form gold colloid monolayer. The above-mentioned gold colloid monolayer It washes, after soaking the above-mentioned glass substrate in 10% methanol solution of 3-aminopropyltrimethoxysilane for 10 minutes, and it is further produced by soaking in a gold colloid solution with a diameter of about 20nm for 2 hours.

[0036] Moreover, it is made for invention according to claim 7 to be the configuration of arbitration where the above-mentioned substrate includes a curved-surface configuration, in invention given in any 1 term of claim 1, claim 2, claim 3, claim 4, claim 5, or claim 6 among this inventions among this inventions.

[0037]

[Embodiment of the Invention] Hereafter, an example of the gestalt of operation of the localization plasmon resonance sensor by this invention is explained to a detail, referring to an attached drawing.

[0038] The conceptual configuration explanatory view of an example of the gestalt of operation of the localization plasmon resonance sensor by this invention is shown in drawing 4 .

[0039] That is, a localization plasmon resonance sensor has the light sources 12, such as laser which carries out incidence of the light beam to the sensor unit 10 and the sensor unit 10, and the spectrophotometer 14 for measuring the absorption-of-light spectrum which penetrated the sensor unit 10, and obtaining an absorbance, and is constituted.

[0040] Here, the sensor unit 10 will fix much particle 10b of with a diameter [about 20nm diameter of about 10-20nm], for example, diameter, gold to glass substrate 10a as a metal particle, will be constituted, and gold colloid monolayer will be formed in the front face of glass substrate 10a of particle 10b of much gold.

[0041] Here, in order to fix much golden particle 10b to the front face of glass substrate 10a and to form gold colloid monolayer in it, the technique shown below can be used.

[0042] That is, after the gold colloid monolayer formed in the front face of glass substrate 10a by fixing golden particle 10b soaks glass substrate 10a in 10% methanol solution of 3-

aminopropyltrimethoxysilane for 10 minutes, it is washed, and it is further produced by soaking in a gold colloid solution with a diameter of about 20nm for 2 hours.

[0043] The image by the scanning electron microscope (SEM) of the gold colloid monolayer formed in the front face of glass substrate 10a by fixing golden particle 10b is shown in drawing 5.

[0044] Particle 10b of the gold which forms gold colloid monolayer is being fixed in the condition of having separated mutually, without hardly condensing so that clearly from the image by the scanning electron microscope shown in this drawing 5.

[0045] And the gold colloid monolayer formed in the front face of glass substrate 10a of the above-mentioned technique is stable also to the organic substance, such as water and alcohol.

[0046] in the above configuration, if the matter adsorbs or accumulates on particle 10b of the gold which forms gold colloid monolayer, the absorbance of the transmitted light will change and detecting will cut that the matter adsorbed or accumulated on golden particle 10b.

[0047] Namely, by irradiating a light beam from the light source 12 to this sensor unit 10, measuring the absorption-of-light spectrum which penetrated particle 10b of the gold fixed to substrate 10a with the spectrophotometer 14, and obtaining an absorbance Since change of the refractive index of the medium which is near the front face of particle 10b of the gold fixed to substrate 10a (to the distance of diameter extent of particle 10b of the gold specifically fixed to substrate 10a) is detectable Consequently, the adsorption and the deposition of the matter in golden particle 10b which were fixed to substrate 10a of the sensor unit 10 can be detected now.

[0048] For example, the absorbance of a resonance peak becomes large and it comes to shift it to a long wavelength side as the thickness of the PMMA thin film 100 deposited as shown in drawing 7 becomes thick, when the PMMA thin film 100 accumulates on particle 10b of the gold fixed to substrate 10a, as shown in drawing 6.

[0049] Therefore, the thickness of the PMMA thin film 100 which deposited further whether the PMMA thin film 100 accumulated on golden particle 10b can also be detected now by detecting change of the absorbance of the transmitted light by which outgoing radiation is carried out from the sensor unit 10 in this case.

[0050] The above-mentioned example is also the same as when other matter adsorbs or it deposits, although it is the case where the PMMA thin film 100 accumulates on particle 10b of the gold fixed to substrate 10a.

[0051] In addition, the gold colloid monolayer formed in the front face of glass substrate 10a by fixing golden particle 10b It washes, after soaking glass substrate 10a in 10% methanol solution of 3-aminopropyltrimethoxysilane for 10 minutes. Furthermore, since it could produce by soaking in a gold colloid solution with a diameter of about 20nm for 2 hours and is moreover stable also to the organic substance, such as water and alcohol Constitute the sensor unit 10 in the shape of [which passes the solution which dissolved the predetermined solvent as shown in drawing 8] a shell, or As shown in drawing 9, the sensor unit 10 can be constituted in the shape of [which holds the solution which dissolved the predetermined solvent] a container, and in this case, while being able to measure the refractive index of the solution concerned, adsorption and deposition of a predetermined solvent in golden particle 10b are also detectable.

[0052] Therefore, according to the above-mentioned localization plasmon resonance sensor, as shown in drawing 10 When the predetermined acceptor 102 is made to stick to particle 10b of the gold fixed to substrate 10a of the sensor unit 10 Since the absorbance of the transmitted light from the sensor unit 10 changes, adsorption of the acceptor 102 is detectable. Moreover, since the absorbance of the transmitted light from the sensor unit 10 changes and adsorption of the predetermined matter 104 can also be detected also when the predetermined matter 104 sticks to an acceptor 102

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PRIOR ART

[Description of the Prior Art] Before, for example, the surface plasmon resonance sensor was used as an affinity sensor for detecting the existence of adsorption of the matter like the existence of adsorption of the antigen in an antigen-antibody reaction.

[0003] Generally this surface plasmon resonance sensor The sensor unit constituted by having the metal membrane which is formed in the whole surface of prism and the prism concerned, and contacts a sample, The light source which generates the light beam for carrying out incidence to the prism of this sensor unit, An optical-system means to carry out incidence of the light beam generated according to this light source to a sensor unit as various incident angles can be acquired to the interface of the prism of a sensor unit, and a metal membrane, It has a detection means to detect the total reflection luminous intensity reflected by the interface of prism and a metal membrane by the incidence of the light beam from the light source to a sensor unit for every various incident angles, and is constituted.

[0004] Therefore, since the sensor unit needed prism as the component, a surface plasmon resonance sensor which was described above had the trouble that arranging prism could not arrange a sensor unit in a difficult narrow location.

[0005] Moreover, in order to obtain the high detection result of precision by the surface plasmon resonance sensor, the whole surface of the prism which forms the metal membrane which contacts a sample in a sensor unit needed to be formed in the smooth flat side, and there was a trouble that a surface plasmon resonance sensor could not be built to the sample of a curved-surface configuration for this reason.

[0006] Moreover, generally the metal membrane formed in the whole surface of prism in a sensor unit is formed using the vacuum deposition method.

[0007] However, there was a trouble that it was difficult to make the inside of the tubular object of a glass tube etc. vapor-deposit a metal membrane depending on a vacuum deposition method, therefore a surface plasmon resonance sensor could not be built in the inside of the tubular object of a glass tube etc.

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EFFECT OF THE INVENTION

[Effect of the Invention] Since this invention is constituted as explained above, it does so the outstanding effectiveness that the localization plasmon resonance sensor which made it possible to arrange in a narrow location can be offered.

[0057] Moreover, since this invention is constituted as explained above, it does so the outstanding effectiveness that the localization plasmon resonance sensor which made it possible to use to the sample of the configuration of arbitration including a curved-surface configuration can be offered.

[0058] Furthermore, since this invention is constituted as explained above, it does so the outstanding effectiveness that the localization plasmon resonance sensor which made it possible to build in the inside of the tubular object of a glass tube etc. can be offered.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The place which this invention is made in view of the various troubles which a Prior art which was described above has, and is made into the purpose tends to offer the localization plasmon resonance sensor which made it possible to arrange in a narrow location. [0009] Moreover, the place made into the purpose of this invention tends to offer the localization plasmon resonance sensor which made it possible to use to the sample of the configuration of arbitration including a curved-surface configuration.

[0010] Furthermore, it is going to offer the localization plasmon resonance sensor which made it possible to build the place made into the purpose of this invention in the inside of the tubular object of a glass tube etc.

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MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, what fixed the metal particle to the front face of the substrate of the ingredient of arbitration, such as a dielectric, a metal, or a semi-conductor, in the shape of film is used for this invention as a sensor unit. By irradiating light to this sensor unit and measuring the absorbance of the light which penetrated the metal particle fixed to the substrate The refractive index of a certain medium can be detected by the distance of diameter extent near [which was fixed to the substrate] the metal particle front face (for example, the metal particle fixed to the substrate), consequently adsorption and deposition of the matter to the metal particle of a sensor unit can be detected now.

[0012] Moreover, since this invention detects the refractive index of a certain medium by the distance of diameter extent near [which was fixed to the substrate] the metal particle front face (for example, the metal particle fixed to the substrate), when the sensor unit has been arranged in a liquid, it can also measure the refractive index of the liquid concerned.

[0013] Here, in case a metal particle is formed in the shape of film on the surface of a substrate, it is desirable to form a metal particle as monolayer and to be fixed in the condition of having separated mutually, moreover, without a metal particle hardly condensing.

[0014] The conceptual explanatory view of the localization plasmon resonance sensor by above-mentioned this invention is shown in drawing 1, the metal particles 3, such as gold and silver, are fixed to a substrate 2, and the sensor unit 1 is constituted.

[0015] And it carries out incidence to a substrate 2 to it, using light of transparent wavelength as incident light to this sensor unit 1. If it does so, incidence of the incident light which penetrated the substrate 2 will be carried out to the metal particle 3, and outgoing radiation of the incident light which penetrated the metal particle 3 will be carried out outside as the transmitted light.

[0016] Here, if incidence of the light is carried out to metal particles, such as gold and silver, the scattered light and absorption will increase in a certain wavelength, a resonance peak will appear, and a resonance wavelength will be dependent on the refractive index of a surrounding medium with localization plasmon resonance at this time. And the absorbance of a resonance peak becomes large and it comes to shift it to a long wavelength side as the refractive index of the surrounding medium of a metal particle becomes large.

[0017] In addition, it is as follows when the conditions of the localization plasmon resonance in the isolated metal particle are shown.

[0018] First, if it assumes that a metal particle is a globular form, the polarizability alpha will be given with a formula 1.

[Equation 1]

$$\alpha = 4\pi a^3 \frac{\epsilon_m - \epsilon_0}{\epsilon_m + 2\epsilon_0}$$

... a formula 1 -- here, as for a, the radius of a ball, epsilon_m, and epsilon₀ are the dielectric constants of a metal particle and a medium, respectively.

[0019] Therefore, [Equation 2]

$$\operatorname{Re}(\epsilon_m) + 2\epsilon_0 = 0$$

... Resonance arises at the time of a formula 2, and the polarizability of a particle becomes max.

[0020] On the other hand, the quenching cross section C_{ext} of a particle is given by the degree type (formula 3) using polarizability α .

[Equation 3]

$$C_{\text{ext}} = \frac{2\pi}{\lambda} \operatorname{Im}(\alpha)$$

... a formula 3 -- here, λ is the wavelength of incident light.

[0021] Therefore, in the resonance conditions given with a formula 2, the quenching cross section C_{ext} of a particle serves as max, and is given by the degree type (formula 4).

[Equation 4]

$$C_{\text{ext}} = \frac{24\pi^2 a^3 (\epsilon_0)^{3/2}}{\lambda \operatorname{Im}(\epsilon_m)}$$

... If the absorption spectrum of the transmitted light which penetrated the formula 4, therefore the metal particle 3 is measured using a spectrophotometer and the absorbance to each wavelength is obtained, as a localization plasmon phenomenon shows to drawing 2, in predetermined wavelength, a resonance peak will appear with the relation between the dielectric constant of the metal particle 3, and the dielectric constant of a surrounding medium ((a) in drawing 2).

[0022] And the matter has not adsorbed and deposited this absorbance at the metal particle 3, and when the surrounding medium of the metal particle 3 concerned is air, it is measured. When the matter with a bigger refractive index than air sticks to the metal particle 3, or it deposits and the matter concerned functions as a surrounding medium of the metal particle 3 concerned, the absorbance of a resonance peak becomes large and it comes ((b) in drawing 2) to shift it to a long wavelength side.

[0023] Therefore, in this invention, by measuring the absorbance of the transmitted light by which outgoing radiation is carried out from the sensor unit 1, the refractive index of a certain medium can be detected by the distance near the front face of the metal particle 3 (for example, diameter extent of the metal particle 3), and the adsorption and the deposition of the matter to the metal particle 3 which were fixed to the substrate 2 of the sensor unit 1 can be detected now.

[0024] Moreover, when the sensor unit 1 has been arranged in a liquid, the refractive index of the liquid concerned can also be measured.

[0025] and the sensor unit 1 makes the metal particle 3 fix to a substrate 2, without needing prism etc. -- being sufficient -- since -- it can arrange in a narrow location.

[0026] Moreover, since you may form in the configuration of arbitration including a curved-surface configuration, the substrate 2 of the sensor unit 1 can be used to the sample of the configuration of arbitration including a curved-surface configuration.

[0027] Furthermore, since immobilization of the metal particle 3 to a substrate 2 can be performed chemically, it can build in the inside of the tubular object of a glass tube etc.

[0028] In this invention in addition, the relation between a substrate and incident light As explained in the above, it may be made to carry out incidence to a substrate 2, using light of transparent wavelength as incident light, referring to drawing 1, and as shown in drawing 3 metal particle 3' fixed to substrate 2' in the light of wavelength which is reflected to substrate 2' -- as incidence is carried out from a side, you may make it measure the absorbance of the reflected light from sensor unit 1', i.e., the transmitted light which penetrated metal particle 3'

[0029] In a viewpoint which was described above among this inventions invention according to claim 1 It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and the

above-mentioned substrate condensing. Light is irradiated to the above-mentioned sensor unit, and the refractive index of the medium near [which was fixed to the above-mentioned substrate / above-mentioned] the metal particle is detected by measuring the absorbance of the light which penetrated the above-mentioned metal particle fixed to the above-mentioned substrate.

[0030] Among this inventions, moreover, invention according to claim 2 It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and the above-mentioned substrate condensing. By irradiating light to the above-mentioned sensor unit, and measuring the absorbance of the light which penetrated the above-mentioned metal particle fixed to the above-mentioned substrate The refractive index of the medium near [which was fixed to the above-mentioned substrate / above-mentioned] the metal particle is detected, and adsorption or deposition of the matter to the above-mentioned metal particle fixed to the above-mentioned substrate of the above-mentioned sensor unit is detected according to this detection result.

[0031] Among this inventions, moreover, invention according to claim 3 It has the sensor unit constituted by having the metal particle fixed as monolayer in the condition of having been isolated mutually, without making the front face of the substrate of arbitration, and the above-mentioned substrate condensing. By irradiating light to the above-mentioned sensor unit arranged in a liquid, and measuring the absorbance of the light which penetrated the above-mentioned metal particle fixed to the above-mentioned substrate The refractive index of the medium near [which was fixed to the above-mentioned substrate / above-mentioned] the metal particle is detected, and the refractive index of the liquid with which the above-mentioned sensor unit has been arranged is measured according to this detection result.

[0032]

[0033] Moreover, it is made for the above-mentioned substrate [in / in / among this inventions / invention given in any 1 term of claim 1, claim 2, or claim 3 / in invention according to claim 4 / the above-mentioned sensor unit] to be a glass substrate among this inventions.

[0034] Moreover, it is made for the above-mentioned metal particle [in / in / among this inventions / invention given in any 1 term of claim 1, claim 2, claim 3, or claim 4 / in invention according to claim 5 / the above-mentioned sensor unit] to be a particle of gold with a diameter of 10-20nm among this inventions.

[0035] Among this inventions, moreover, invention according to claim 6 It sets to invention according to claim 4 among this inventions. The above-mentioned sensor unit Fix a golden particle to the front face of the above-mentioned glass substrate as the above-mentioned metal particle, and it comes to form gold colloid monolayer. The above-mentioned gold colloid monolayer It washes, after soaking the above-mentioned glass substrate in 10% methanol solution of 3-aminopropyltrimethoxysilane for 10 minutes, and it is further produced by soaking in a gold colloid solution with a diameter of about 20nm for 2 hours.

[0036] Moreover, it is made for invention according to claim 7 to be the configuration of arbitration where the above-mentioned substrate includes a curved-surface configuration, in invention given in any 1 term of claim 1, claim 2, claim 3, claim 4, claim 5, or claim 6 among this inventions among this inventions.

[0037]

[Embodiment of the Invention] Hereafter, an example of the gestalt of operation of the localization plasmon resonance sensor by this invention is explained to a detail, referring to an attached drawing.

[0038] The conceptual configuration explanatory view of an example of the gestalt of operation of the localization plasmon resonance sensor by this invention is shown in drawing 4 .

[0039] That is, a localization plasmon resonance sensor has the light sources 12, such as laser which carries out incidence of the light beam to the sensor unit 10 and the sensor unit 10, and the spectrophotometer 14 for measuring the absorption-of-light spectrum which penetrated the sensor unit 10, and obtaining an absorbance, and is constituted.

[0040] Here, the sensor unit 10 will fix much particle 10b of with a diameter [about 20nm diameter of

about 10-20nm], for example, diameter, gold to glass substrate 10a as a metal particle, will be constituted, and gold colloid monolayer will be formed in the front face of glass substrate 10a of particle 10b of much gold.

[0041] Here, in order to fix much golden particle 10b to the front face of glass substrate 10a and to form gold colloid monolayer in it, the technique shown below can be used.

[0042] That is, after the gold colloid monolayer formed in the front face of glass substrate 10a by fixing golden particle 10b soaks glass substrate 10a in 10% methanol solution of 3-aminopropyltrimethoxysilane for 10 minutes, it is washed, and it is further produced by soaking in a gold colloid solution with a diameter of about 20nm for 2 hours.

[0043] The image by the scanning electron microscope (SEM) of the gold colloid monolayer formed in the front face of glass substrate 10a by fixing golden particle 10b is shown in drawing 5.

[0044] Particle 10b of the gold which forms gold colloid monolayer is being fixed in the condition of having separated mutually, without hardly condensing so that clearly from the image by the scanning electron microscope shown in this drawing 5.

[0045] And the gold colloid monolayer formed in the front face of glass substrate 10a of the above-mentioned technique is stable also to the organic substance, such as water and alcohol.

[0046] in the above configuration, if the matter adsorbs or accumulates on particle 10b of the gold which forms gold colloid monolayer, the absorbance of the transmitted light will change and detecting will cut that the matter adsorbed or accumulated on golden particle 10b.

[0047] Namely, by irradiating a light beam from the light source 12 to this sensor unit 10, measuring the absorption-of-light spectrum which penetrated particle 10b of the gold fixed to substrate 10a with the spectrophotometer 14, and obtaining an absorbance Since change of the refractive index of the medium which is near the front face of particle 10b of the gold fixed to substrate 10a (to the distance of diameter extent of particle 10b of the gold specifically fixed to substrate 10a) is detectable Consequently, the adsorption and the deposition of the matter in golden particle 10b which were fixed to substrate 10a of the sensor unit 10 can be detected now.

[0048] For example, the absorbance of a resonance peak becomes large and it comes to shift it to a long wavelength side as the thickness of the PMMA thin film 100 deposited as shown in drawing 7 becomes thick, when the PMMA thin film 100 accumulates on particle 10b of the gold fixed to substrate 10a, as shown in drawing 6.

[0049] Therefore, the thickness of the PMMA thin film 100 which deposited further whether the PMMA thin film 100 accumulated on golden particle 10b can also be detected now by detecting change of the absorbance of the transmitted light by which outgoing radiation is carried out from the sensor unit 10 in this case.

[0050] The above-mentioned example is also the same as when other matter adsorbs or it deposits, although it is the case where the PMMA thin film 100 accumulates on particle 10b of the gold fixed to substrate 10a.

[0051] In addition, the gold colloid monolayer formed in the front face of glass substrate 10a by fixing golden particle 10b It washes, after soaking glass substrate 10a in 10% methanol solution of 3-aminopropyltrimethoxysilane for 10 minutes. Furthermore, since it could produce by soaking in a gold colloid solution with a diameter of about 20nm for 2 hours and is moreover stable also to the organic substance, such as water and alcohol Constitute the sensor unit 10 in the shape of [which passes the solution which dissolved the predetermined solvent as shown in drawing 8] a shell, or As shown in drawing 9, the sensor unit 10 can be constituted in the shape of [which holds the solution which dissolved the predetermined solvent] a container, and in this case, while being able to measure the refractive index of the solution concerned, adsorption and deposition of a predetermined solvent in golden particle 10b are also detectable.

[0052] Therefore, according to the above-mentioned localization plasmon resonance sensor, as shown in drawing 10 When the predetermined acceptor 102 is made to stick to particle 10b of the gold fixed to substrate 10a of the sensor unit 10 Since the absorbance of the transmitted light from the sensor unit 10 changes, adsorption of the acceptor 102 is detectable. Moreover, since the absorbance of the transmitted

light from the sensor unit 10 changes and adsorption of the predetermined matter 104 can also be detected also when the predetermined matter 104 sticks to an acceptor 102 It is effective if it uses as an affinity sensor which detects the existence of adsorption of the antigen in an antigen-antibody reaction. [0053] In addition, in the gestalt of this operation, although the golden particle was used as a metal particle, of course, it is not what is restricted to this, and the metal particle of silver or others can be used.

[0054] However, when a golden particle is used as a metal particle, since gold is the stable matter, the handling is easy, and when a silver particle is used as a metal particle, highly sensitive measurement can be performed.

[0055] Moreover, in the gestalt of this operation, although the glass substrate was used as a substrate, of course, it is not what is restricted to this, and the substrate of the ingredient of arbitration, such as dielectric metallurgy groups other than glass or a semi-conductor, can be used.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the conceptual explanatory view of the localization plasmon resonance sensor by this invention.

[Drawing 2] It is the graph which shows the absorbance of the transmitted light of the localization plasmon resonance sensor by this invention.

[Drawing 3] It is the conceptual explanatory view of the localization plasmon resonance sensor by this invention.

[Drawing 4] It is the conceptual configuration explanatory view of an example of the gestalt of operation of the localization plasmon resonance sensor by this invention.

[Drawing 5] It is an image by the scanning electron microscope (SEM) of the gold colloid monolayer formed in the front face of a glass substrate by fixing a golden particle.

[Drawing 6] It is the conceptual explanatory view showing the condition that the PMMA thin film accumulated on the particle of the gold of a sensor unit.

[Drawing 7] It is the graph which shows the absorbance of the transmitted light of the localization plasmon resonance sensor which the PMMA thin film deposited on the particle of the gold of a sensor unit.

[Drawing 8] It is the conceptual explanatory view of the sensor unit constituted in the shape of a shell.

[Drawing 9] It is the conceptual explanatory view of the sensor unit constituted in the shape of a container.

[Drawing 10] It is a conceptual explanatory view at the time of using the localization plasmon resonance sensor by this invention as an affinity sensor.

[Description of Notations]

1 1' Sensor unit

2 2' Substrate

3 3' Metal particle

10 Sensor Unit

10a A glass substrate

10b A golden particle

12 Light Source

14 Spectrophotometer

100 PMMA Thin Film

102 Acceptor

104 Matter

[Translation done.]

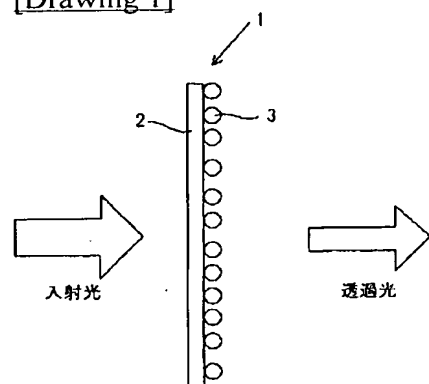
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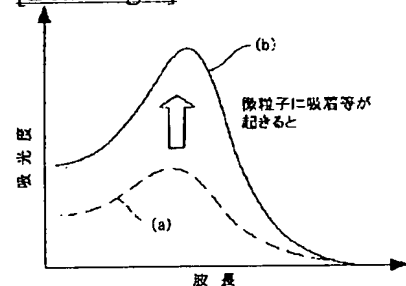
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DRAWINGS

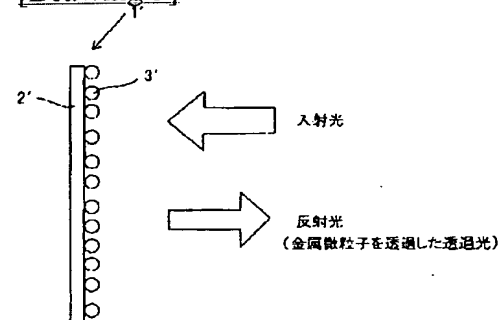
[Drawing 1]



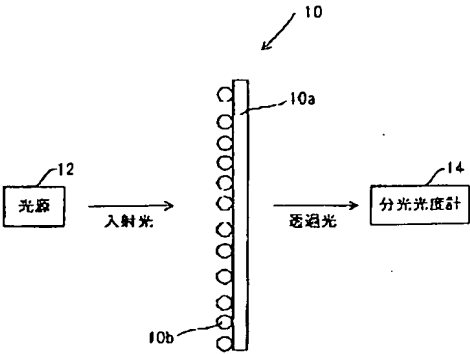
[Drawing 2]



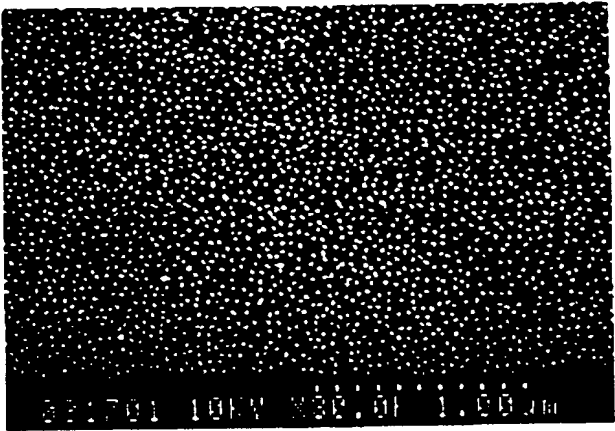
[Drawing 3]



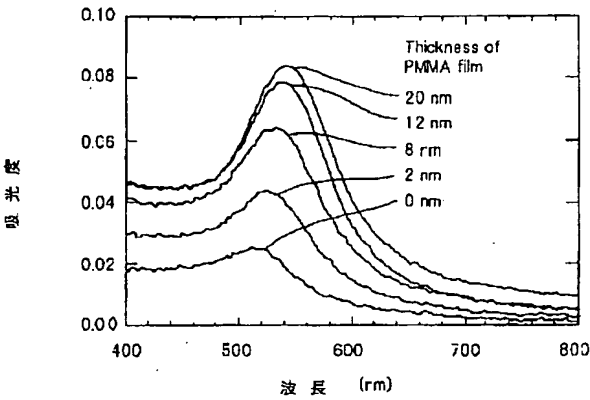
[Drawing 4]



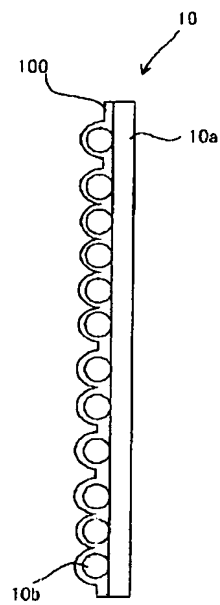
[Drawing 5]
SEM image of 20-nm gold colloid monolayer



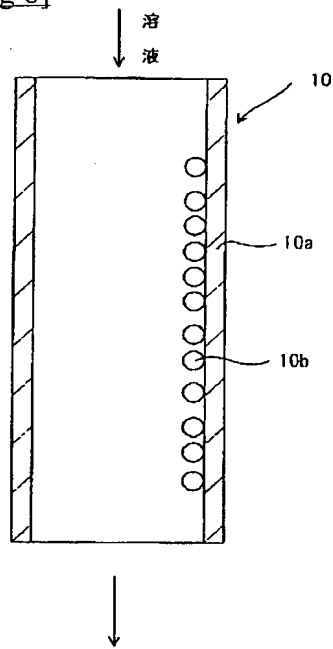
[Drawing 7]



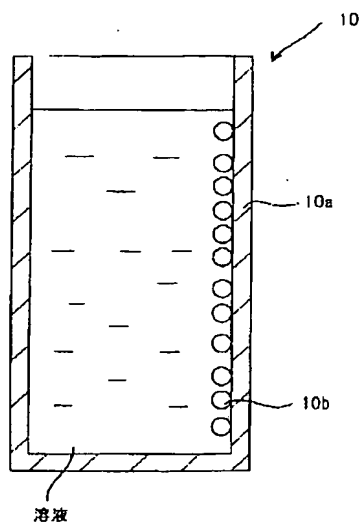
[Drawing 6]



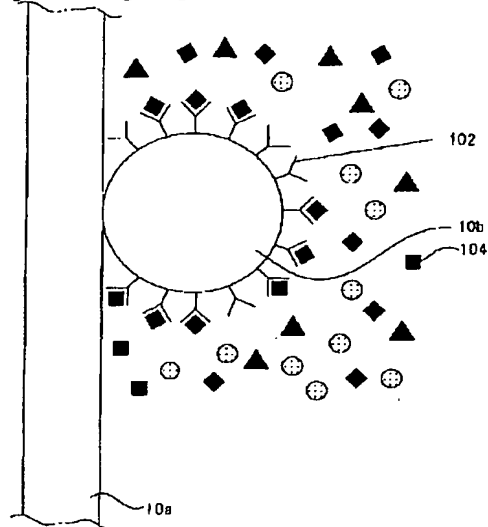
[Drawing 8]



[Drawing 9]



[Drawing 10]



[Translation done.]